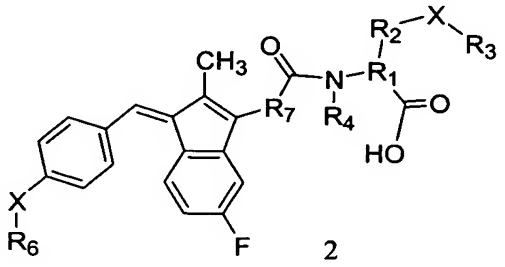
1. A non-naturally occurring compound comprising at least one methyl sulfide or methyl sulfoxide moiety, the compound being a substrate for at least one MsrA enzyme and at least one MsrB enzyme, or a pharmaceutically acceptable salt thereof.

2. The compound of claim 1, having formula 2, or a pharmaceutically acceptable salt thereof:

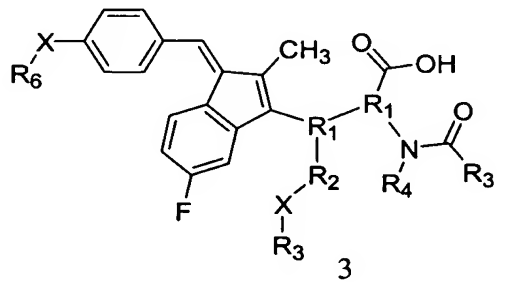


2

wherein:

R_1 is CH of either *R* or *S* configuration; R_2 is a normal or branched alkyl or fluoroalkyl group having 1 to 6 carbons; R_3 is methyl or ethyl or a fluorinated derivative thereof; R_4 is a hydrogen or a normal or branched alkyl group having 1 to 6 carbons; R_5 is a CH of either *R* or *S* configuration; R_6 is a hydrogen or a normal or branched alkyl or fluoroalkyl group having 1 to 6 carbons; R_7 is a nitrogen with substituent R_4 as defined herein, a CH of either *R* or *S* configuration, or a normal or branched alkyl or fluoroalkyl group having 1 to 6 carbons; and X is either S or Se in any oxidation state.

3. The compound of claim 1, having formula 3, or a pharmaceutically acceptable salt thereof.:

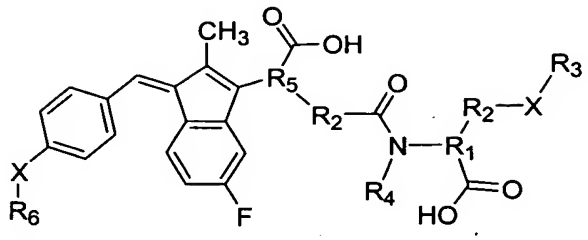


3

wherein:

R_1 is CH of either *R* or *S* configuration; R_2 is a normal or branched alkyl or fluoroalkyl group having 1 to 6 carbons; R_3 is methyl or ethyl or a fluorinated derivative thereof; R_4 is a hydrogen or a normal or branched alkyl group having 1 to 6 carbons; R_5 is a CH of either *R* or *S* configuration; R_6 is a hydrogen or a normal or branched alkyl or fluoroalkyl group having 1 to 6 carbons; and X is either S or Se in any oxidation state.

4. The compound of claim 1, having formula 4, or a pharmaceutically acceptable salt thereof:

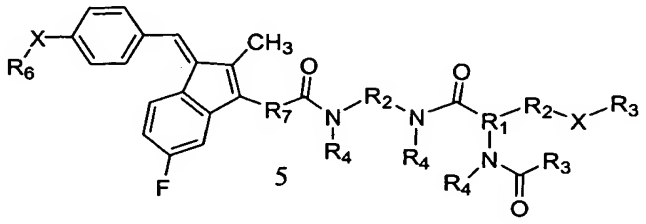


4

wherein:

R_1 is CH of either *R* or *S* configuration; R_2 is a normal or branched alkyl or fluoroalkyl group having 1 to 6 carbons; R_3 is methyl or ethyl or a fluorinated derivative thereof; R_4 is a hydrogen or a normal or branched alkyl group having 1 to 6 carbons; R_5 is a CH of either *R* or *S* configuration; R_6 is a hydrogen or a normal or branched alkyl or fluoroalkyl group having 1 to 6 carbons; and X is either S or Se in any oxidation state.

5. The compound of claim 1, having formula 5, or a pharmaceutically acceptable salt thereof:

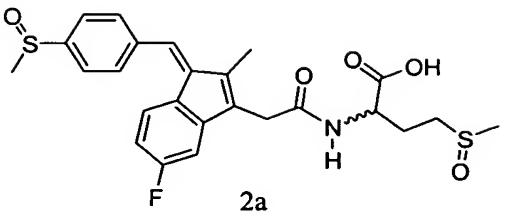


5

wherein:

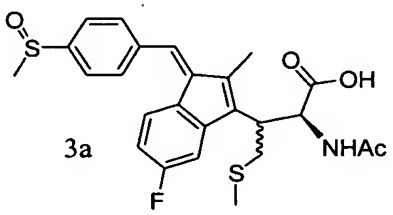
R_1 is CH of either *R* or *S* configuration; R_2 is a normal or branched alkyl or fluoroalkyl group having 1 to 6 carbons; R_3 is methyl or ethyl or a fluorinated derivative thereof; R_4 is a hydrogen or a normal or branched alkyl group having 1 to 6 carbons; and X is either S or Se in any oxidation state.

6. The compound of claim 1, having formula 2a, or a pharmaceutically acceptable salt thereof:



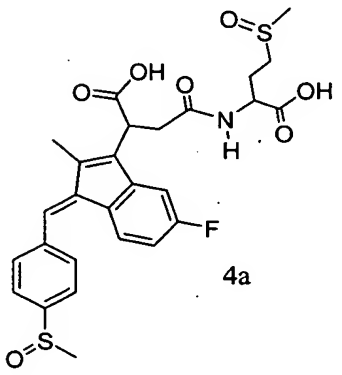
2a

7. The compound of claim 1, having formula 3a, or a pharmaceutically acceptable salt thereof.



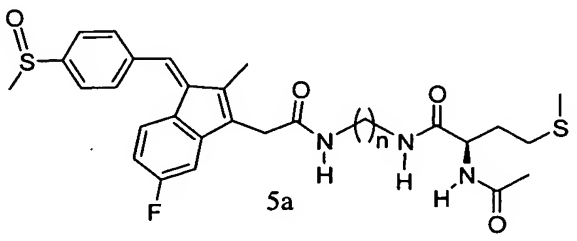
3a

8. The compound of claim 1, having formula 4a, or a pharmaceutically acceptable salt thereof.



4a

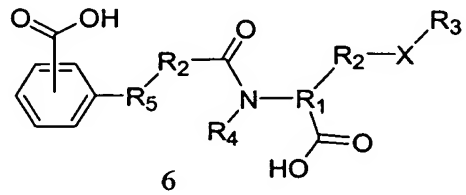
9. The compound of claim 1, having formula 5a, or a pharmaceutically acceptable salt thereof.



5a

10. A non-naturally occurring compound comprising at least one methyl sulfide or methyl sulfoxide moiety, the compound being a substrate for at least one Msr enzyme, said compound having a backbone not based on sulindac (1(Z)-5-fluoro-2-methyl-1[[4-(methylsulfinyl)phenyl)methylene]-1H-indenyl-3-acetic acid).

11. The compound of claim 10 having formula 6, or a pharmaceutically acceptable salt thereof:

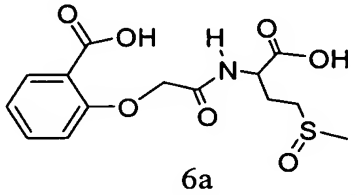


6

wherein:

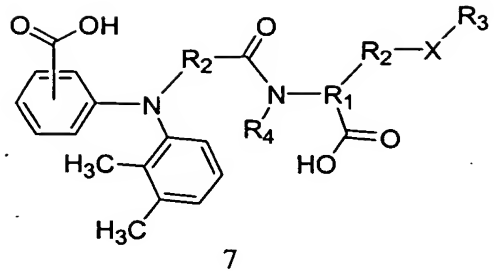
the aromatic ring includes one or more nitrogen atoms; the aromatic carboxyl group is oriented *ortho*, *meta*, or *para* to the methionine-based moiety; R_1 is CH of either *R* or *S* configuration; R_2 is a normal or branched alkyl or fluoroalkyl group having 1 to 6 carbons; R_3 is methyl or ethyl or a fluorinated derivative thereof; R_4 is a hydrogen or a normal or branched alkyl group having 1 to 6 carbons; R_5 is a nitrogen with substituent R_4 as defined herein, an oxygen, or a sulfur; and X is S or Se in any oxidation state.

12. The compound of claim 10 having formula 6a, or a pharmaceutically acceptable salt thereof:



6a

13. The compound of claim 10 having formula 7, or a pharmaceutically acceptable salt thereof:

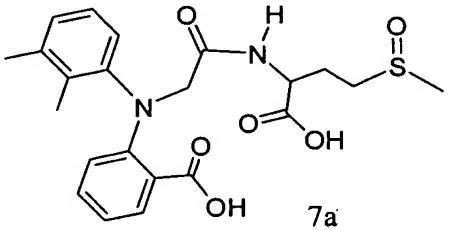


7

wherein:

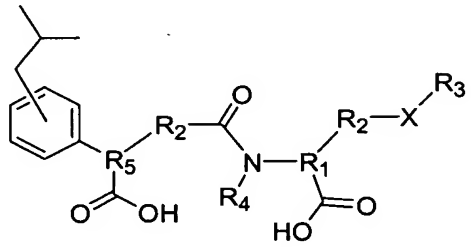
both aromatic rings comprises one or more nitrogen atoms; the aromatic carboxyl group is oriented *ortho*, *meta*, or *para* to the aniline nitrogen; R_1 is CH of either *R* or *S* configuration; R_2 is normal or branched alkyl or fluoroalkyl group having 1 to 6 carbons; R_3 is methyl or ethyl or a fluorinated derivative thereof; R_4 is a hydrogen or a normal or branched alkyl group having 1 to 6 carbons; and X is S or Se in any oxidation state.

14. The compound of claim 10 having formula 7a, or a pharmaceutically acceptable salt thereof:



7a

15. The compound of claim 10 having formula 8, or a pharmaceutically acceptable salt thereof:



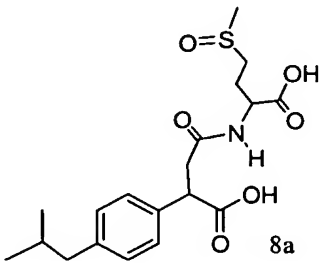
8

wherein:

the aromatic ring comprises one or more nitrogen atoms; the *sec*-butyl group is oriented *ortho*, *meta*, or *para* to the methionine-based moiety; R_1 is CH of either *R* or *S* configuration; R_2 is a normal or branched alkyl or fluoroalkyl group having 1to 6 carbons; R_3 is methyl or ethyl or a fluorinated derivative thereof; R_4 is a hydrogen or a normal or branched alkyl group

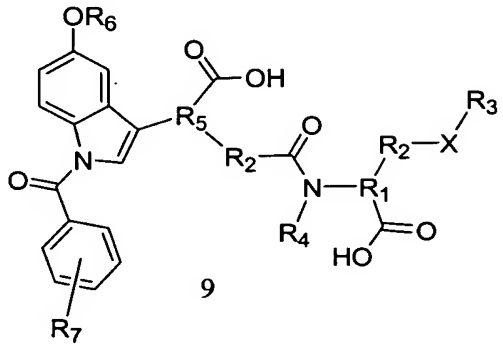
having 1 to 6 carbons; R_5 is a CH of either *R* or *S* configuration; X is either S or Se in any oxidation state.

16. The compound of claim 10 having formula 8a, or a pharmaceutically acceptable salt thereof.



8a

17. The compound of claim 10 having formula 9, or a pharmaceutically acceptable salt thereof:



9

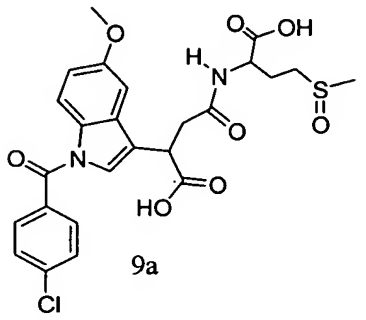
wherein:

Groups R_1, R_2, R_3, R_4, R_5, R_6, R_7 and X in general structure 9 are defined as follows:

R_1 is CH of either *R* or *S* configuration; R_2 is a normal or branched alkyl or fluoroalkyl group having 1 to 6 carbons; R_3 is methyl or ethyl or a fluorinated derivative thereof;

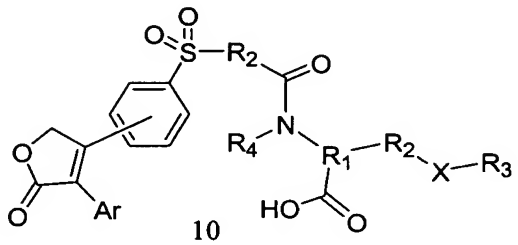
R_4 is a hydrogen or a normal or branched alkyl group having 1 to 6 carbons; R_5 is a CH of either *R* or *S* configuration; R_6 is a hydrogen or a normal or branched alkyl or fluoroalkyl group having 1 to 6 carbons; R_7 is any halogen oriented *ortho*, *meta*, or *para* to the carbonyl group, and X is S or Se in any oxidation state.

18. The compound of claim 10 having formula 9a, or a pharmaceutically acceptable salt thereof:



9a

19. The compound of claim 10 having formula 10, or a pharmaceutically acceptable salt thereof:

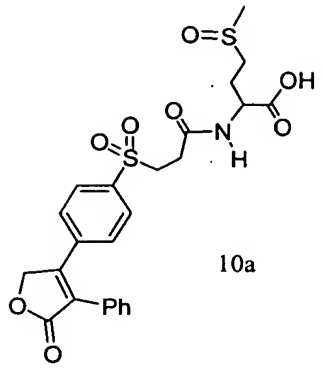


10

wherein:

the lactone ring is oriented *ortho*, *meta*, or *para* to the sulfonyl group; R_1 is CH of either *R* or *S* configuration; R_2 is a normal or branched alkyl or fluoroalkyl group having 1 to 6 carbons; R_3 is methyl or ethyl or a fluorinated derivative thereof; R_4 is a hydrogen or a normal or branched alkyl group having 1 to 6 carbons; X is S or Se in any oxidation state; Ar is a phenyl, alkyl, halogen substituted phenyl, or heteroaromatic compound.

20. The compound of claim 10 having formula 10a, or a pharmaceutically acceptable salt thereof:



10a

21. A composition comprising the compound of claim 1 and a pharmaceutically acceptable carrier.

22. A composition comprising the compound of claim 10 and a pharmaceutically acceptable carrier.

23. A method for reducing, preventing or reversing oxidative damage in a cell, the method comprising the steps of:

(a) providing a non-naturally occurring compound comprising at least one methyl sulfide or methyl sulfoxide moiety, the compound being a substrate for at least one Msr enzyme;

(b) providing a cell expressing at least one Msr enzyme, said cell comprising or being exposed to reactive oxygen species; and

(c) contacting the cell with an amount of the compound sufficient to reduce, prevent, or reverse oxidative damage in the cell by said reactive oxygen species.

24. The method of claim 23, wherein the cell is within an animal subject.

25. The method of claim 23, wherein the animal subject has a condition or disorder associated with oxidative damage.

26. The method of claim 23, wherein the disorder involves degeneration of a nerve cell.

27. The method of claim 23, wherein the condition is age-related.

28. A method for extending the lifespan of an animal comprising administering to the animal a therapeutically effective amount of a non-naturally occurring compound comprising at least one methyl sulfide or methyl sulfoxide moiety, the compound being a substrate for at least one Msr enzyme.